FIG.1

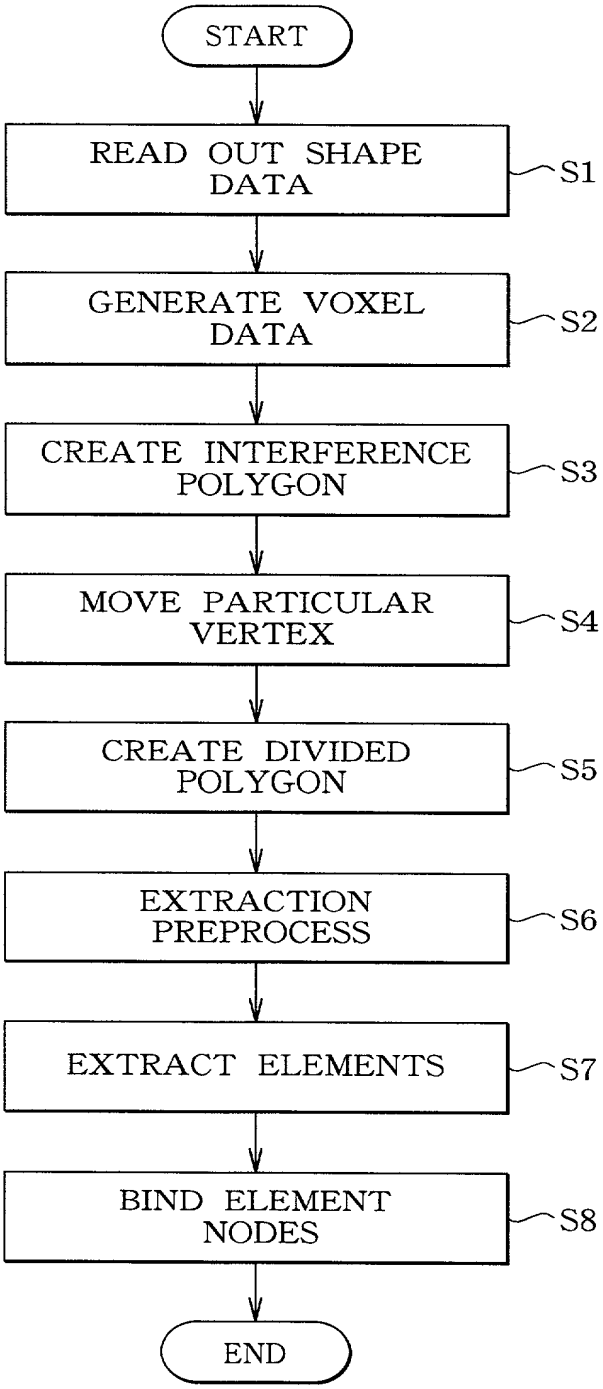

START
READ OUT SHAPE DATA
S1
GENERATE VOXEL DATA
S2
CREATE INTERFERENCE POLYGON
S3
MOVE PARTICULAR VERTEX
S4
CREATE DIVIDED POLYGON
S5
EXTRACTION PREPROCESS
S6
EXTRACT ELEMENTS
S7
BIND ELEMENT NODES
S8
END

FIG.2(A)

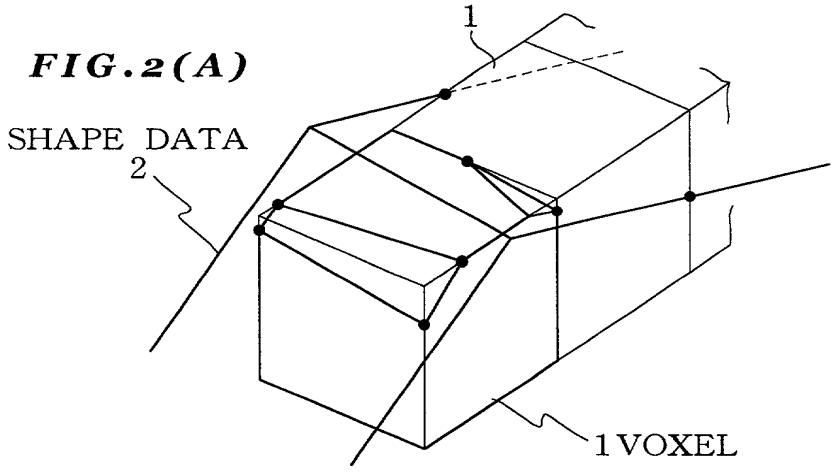


FIG.2(B)

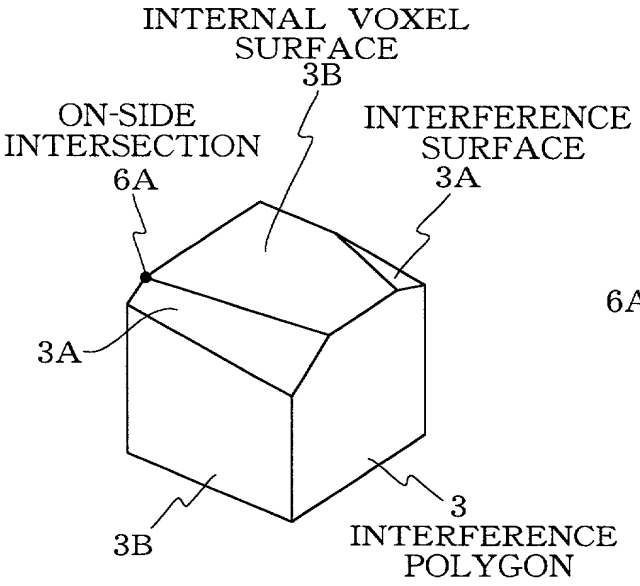


FIG.2(C)

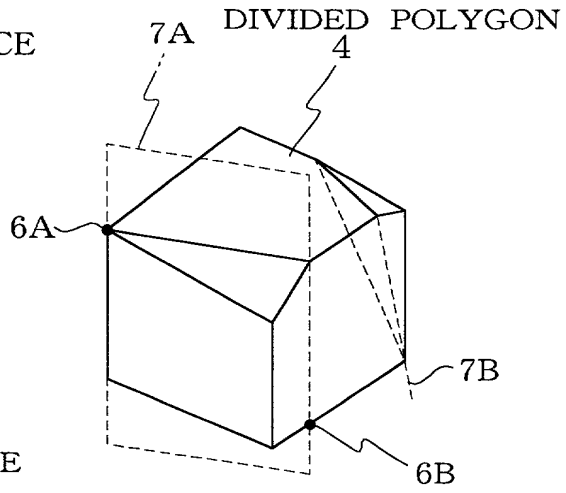


FIG.2(D)

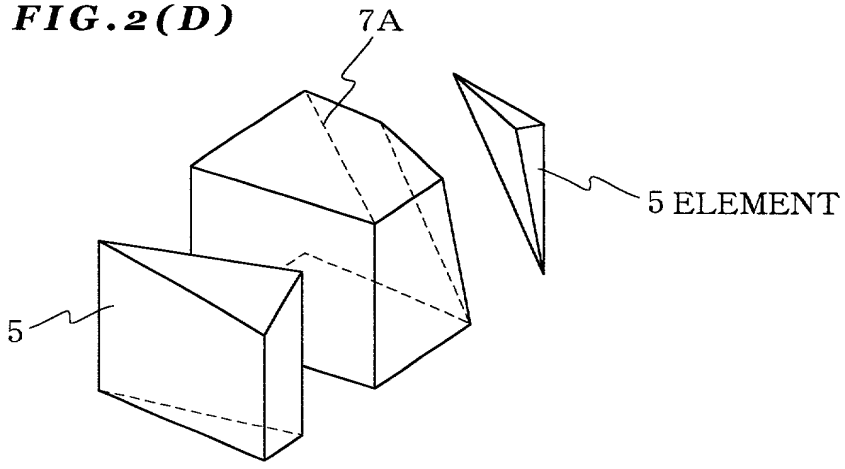


FIG. 3

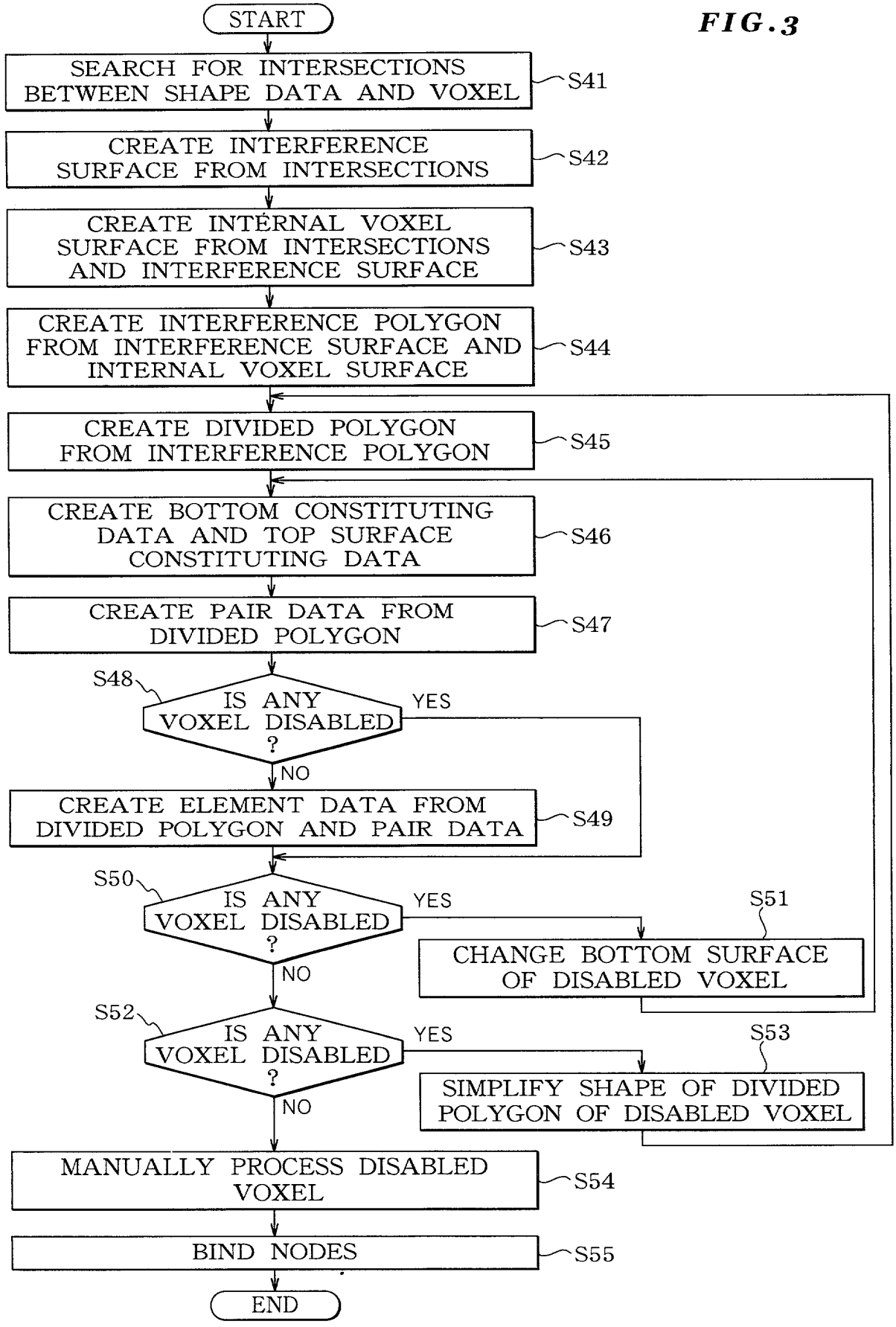

START
SEARCH FOR INTERSECTIONS BETWEEN SHAPE DATA AND VOXEL
S41
CREATE INTERFERENCE SURFACE FROM INTERSECTIONS
S42
CREATE INTERNAL VOXEL SURFACE FROM INTERSECTIONS AND INTERFERENCE SURFACE
S43
CREATE INTERFERENCE POLYGON FROM INTERFERENCE SURFACE AND INTERNAL VOXEL SURFACE
S44
CREATE DIVIDED POLYGON FROM INTERFERENCE POLYGON
S45
CREATE BOTTOM CONSTITUTING DATA AND TOP SURFACE CONSTITUTING DATA
S46
CREATE PAIR DATA FROM DIVIDED POLYGON
S47
S48
IS ANY VOXEL DISABLED ?
YES
NO
CREATE ELEMENT DATA FROM DIVIDED POLYGON AND PAIR DATA
S49
S50
IS ANY VOXEL DISABLED ?
YES
S51
CHANGE BOTTOM SURFACE OF DISABLED VOXEL
NO
S52
IS ANY VOXEL DISABLED ?
YES
S53
SIMPLIFY SHAPE OF DIVIDED POLYGON OF DISABLED VOXEL
NO
MANUALLY PROCESS DISABLED VOXEL
S54
BIND NODES
S55
END

FIG. 4

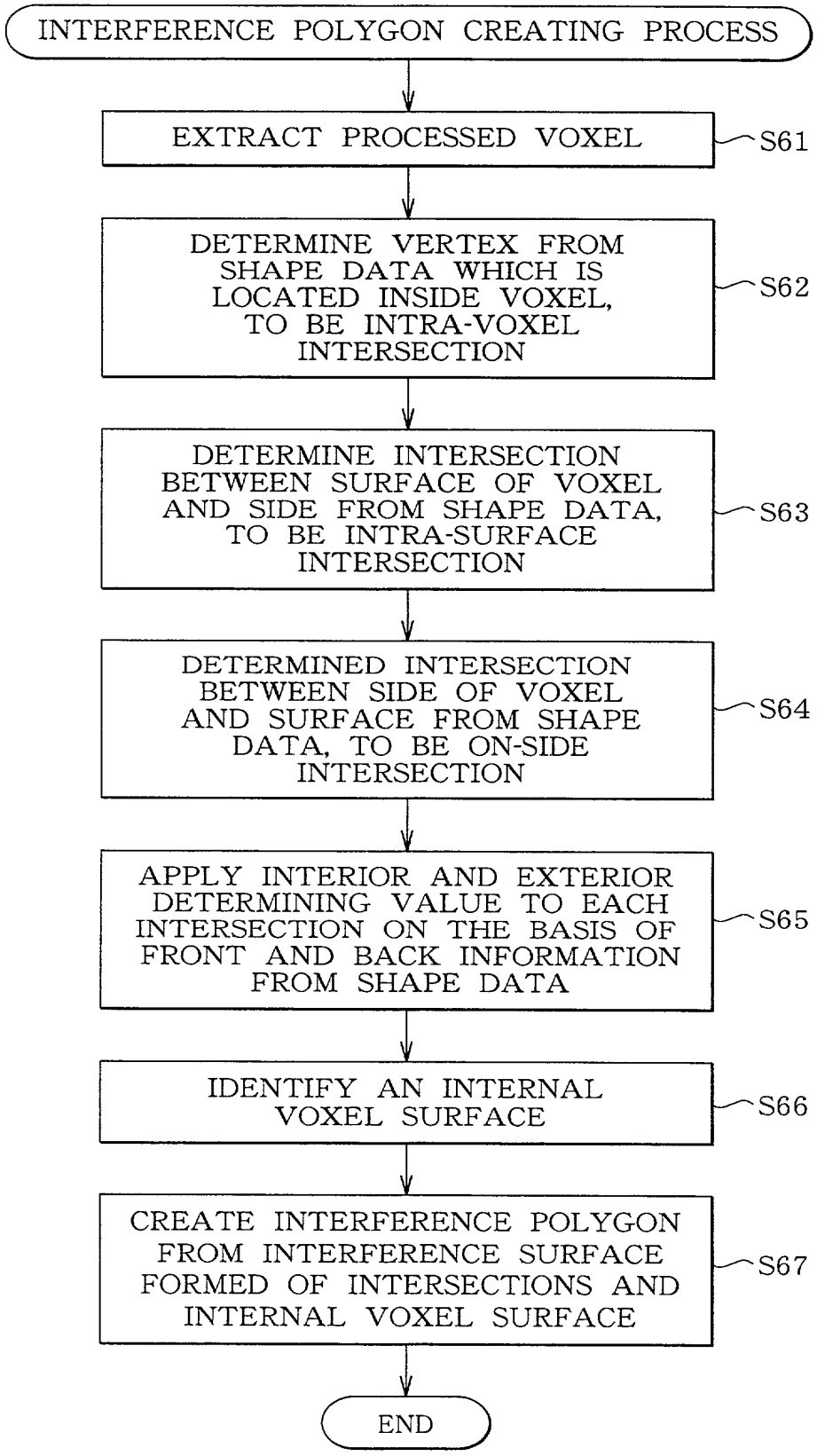
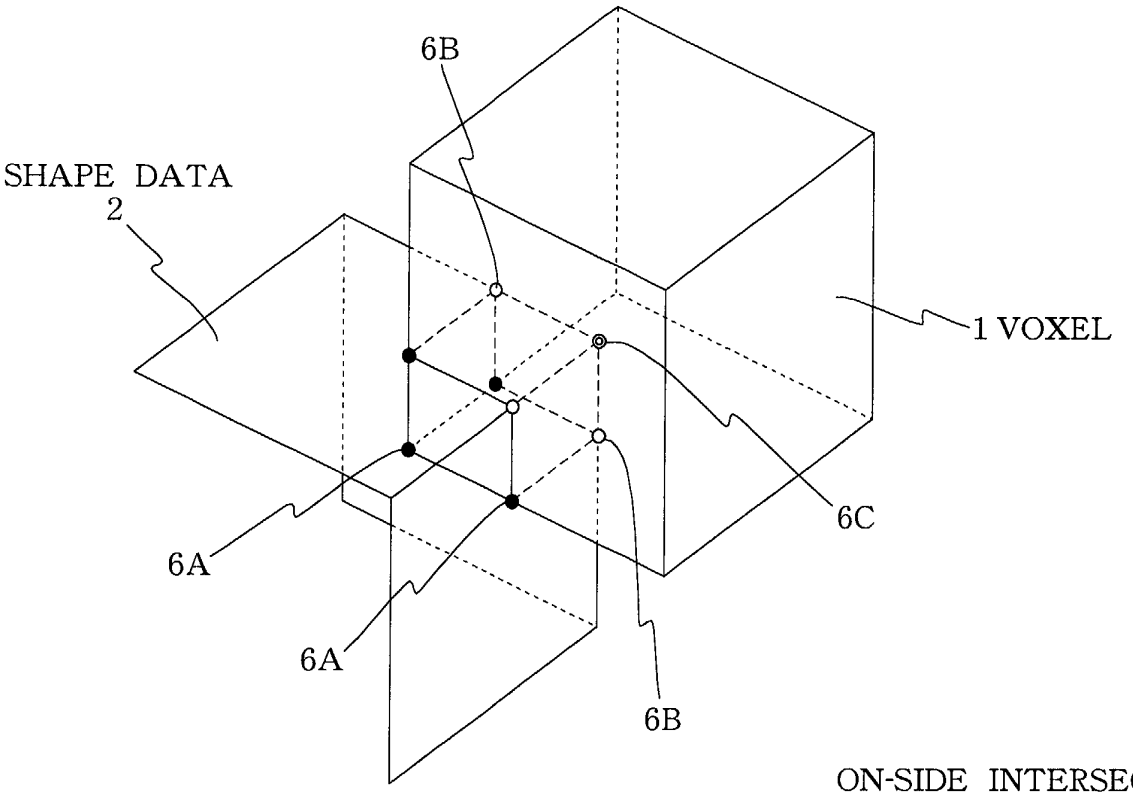

INTERFERENCE POLYGON CREATING PROCESS
EXTRACT PROCESSED VOXEL
S61
DETERMINE VERTEX FROM SHAPE DATA WHICH IS LOCATED INSIDE VOXEL, TO BE INTRA-VOXEL INTERSECTION
S62
DETERMINE INTERSECTION BETWEEN SURFACE OF VOXEL AND SIDE FROM SHAPE DATA, TO BE INTRA-SURFACE INTERSECTION
S63
DETERMINED INTERSECTION BETWEEN SIDE OF VOXEL AND SURFACE FROM SHAPE DATA, TO BE ON-SIDE INTERSECTION
S64
APPLY INTERIOR AND EXTERIOR DETERMINING VALUE TO EACH INTERSECTION ON THE BASIS OF FRONT AND BACK INFORMATION FROM SHAPE DATA
S65
IDENTIFY AN INTERNAL VOXEL SURFACE
S66
CREATE INTERFERENCE POLYGON FROM INTERFERENCE SURFACE FORMED OF INTERSECTIONS AND INTERNAL VOXEL SURFACE
S67
END

FIG.5



ON-SIDE INTERSECTION 6A : ●
INTRA-SURFACE INTERSECTION 6B : ○
INTRA-VOXEL INTERSECTION 6C : ◎

FIG.6(A)

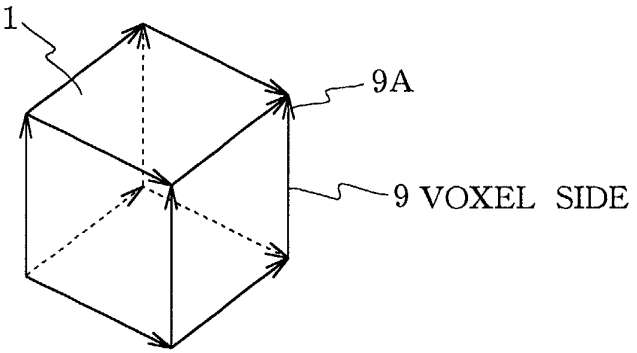


FIG.6(B)

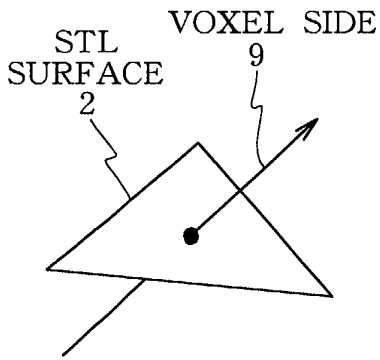
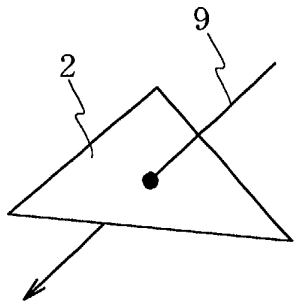
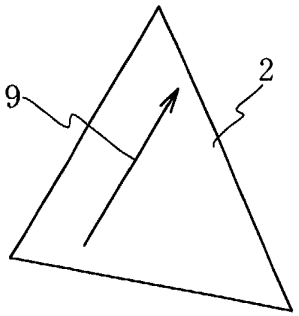
FRONT AND BACK OF SHAPE DATA			
INTERIOR AND EXTERIOR DETERMINING VALUE	(1) POSITIVE DIRECTION OF SIDE IS OUTWARD, AND NEGATIVE DIRECTION THEREOF IS INWARD ⬇ 「+」	(2) POSITIVE DIRECTION OF SIDE IS INWARD, AND NEGATIVE DIRECTION THEREOF IS OUTWARD ⬇ 「−」	(3) BOTH DIRECTIONS OF SIDE ARE ON BOUNDARY ⬇ 「BOUNDARY」

FIG.7(A)

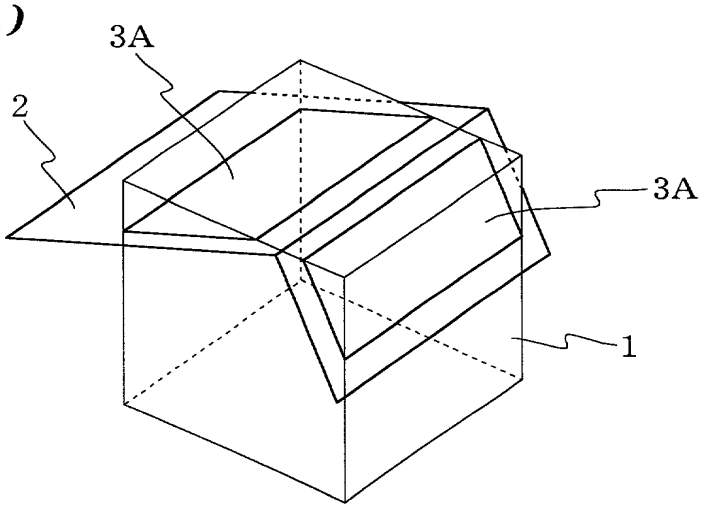


FIG.7(B)

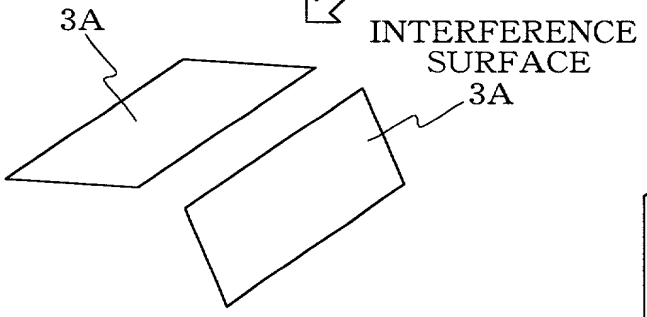
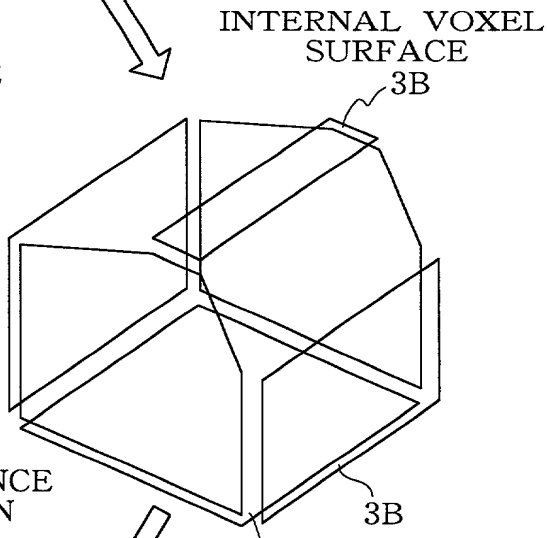


FIG.7(C)



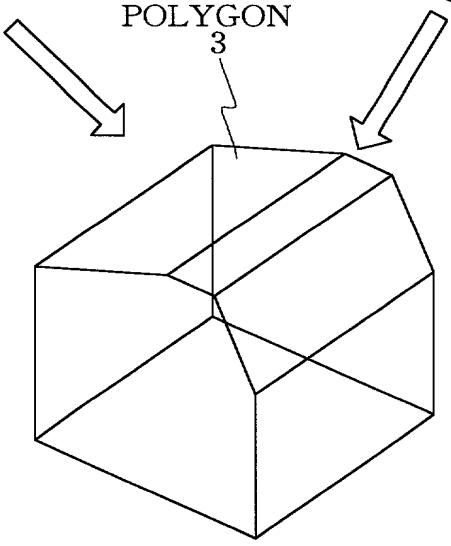


FIG.7(D)

JP2003-346180-A-6545-6560

FIG.8(A)

ONLY ON-SIDE INTERSECTIONS

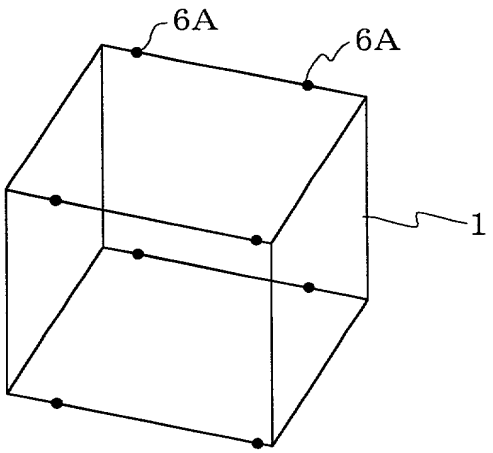
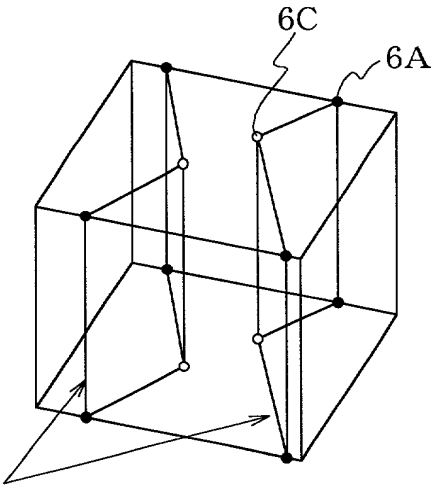


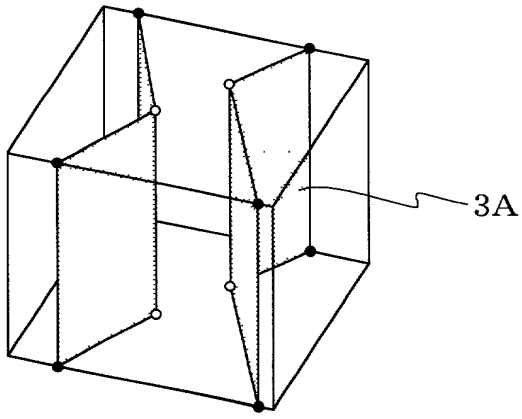
FIG.8(B)

INTRA-SURFACE INTERSECTIONS INCLUDED



SHAPE OF THE SHAPE DATA INSIDE THE VOXEL

FIG.8(C)



○: ON-SIDE INTERSECTION
●: INTRA-SURFACE INTERSECTION

FIG.9

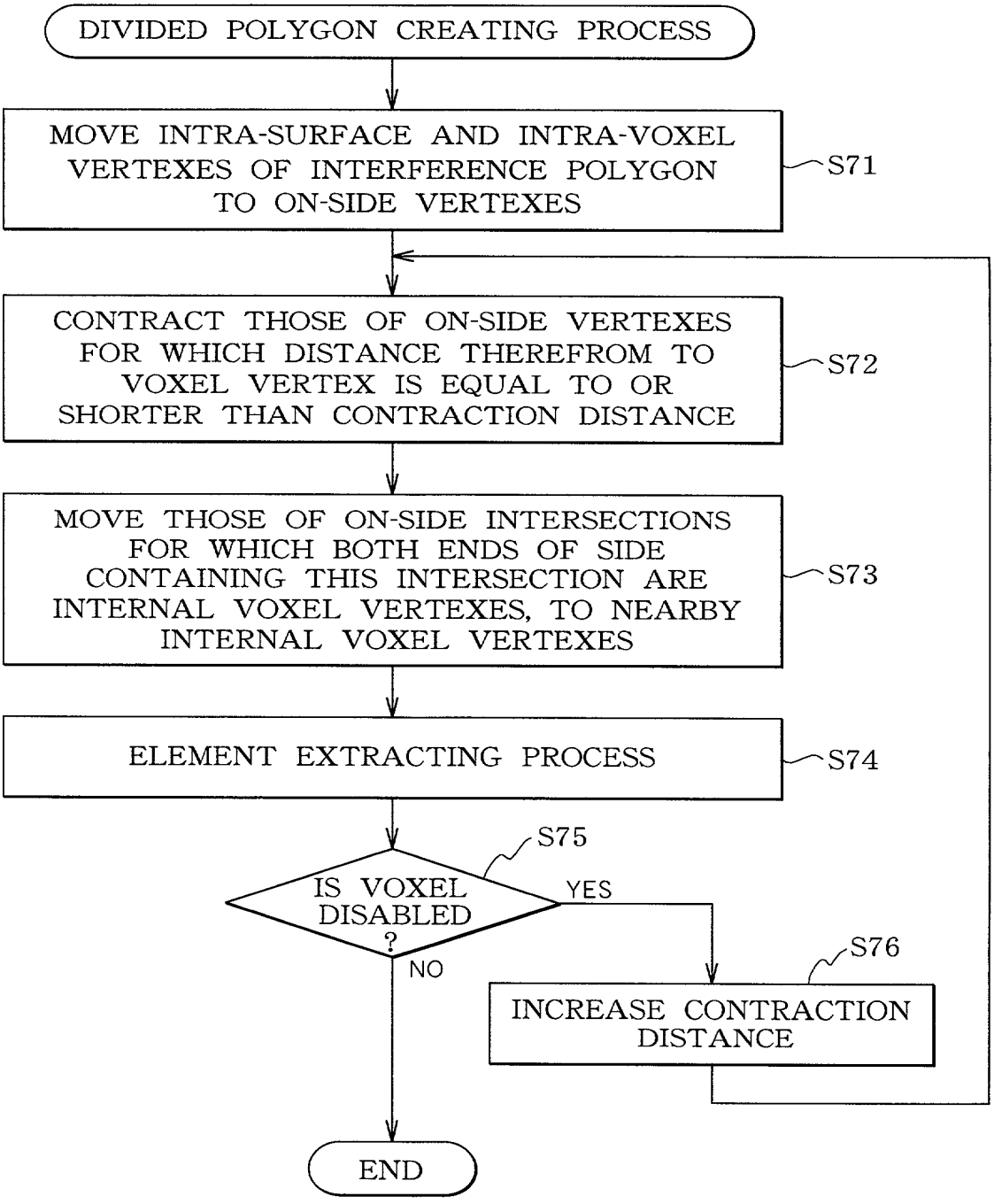
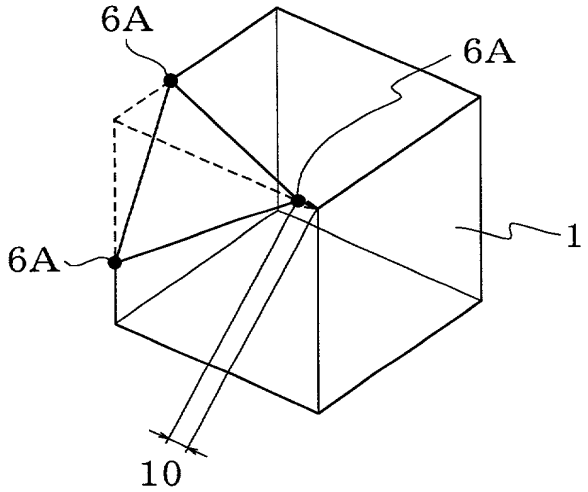
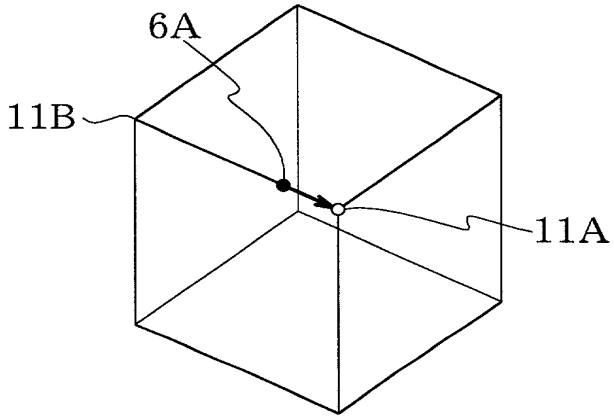

DIVIDED POLYGON CREATING PROCESS
MOVE INTRA-SURFACE AND INTRA-VOXEL VERTEXES OF INTERFERENCE POLYGON TO ON-SIDE VERTEXES
S71
CONTRACT THOSE OF ON-SIDE VERTEXES FOR WHICH DISTANCE THEREFROM TO VOXEL VERTEX IS EQUAL TO OR SHORTER THAN CONTRACTION DISTANCE
S72
MOVE THOSE OF ON-SIDE INTERSECTIONS FOR WHICH BOTH ENDS OF SIDE CONTAINING THIS INTERSECTION ARE INTERNAL VOXEL VERTEXES, TO NEARBY INTERNAL VOXEL VERTEXES
S73
ELEMENT EXTRACTING PROCESS
S74
S75
IS VOXEL DISABLED ?
YES
NO
S76
INCREASE CONTRACTION DISTANCE
END

FIG.10(A)



(——): VOXEL
(- - - -): INTERFERENCE POLYGON

FIG.10(B)



SOLID LINE (—): INTERFERENCE POLYGON
BLACK CIRCLE (●): SOURCE VERTEX 6A
WHITE CIRCLE (○): DESTINATION VERTEX 11A

FIG.11

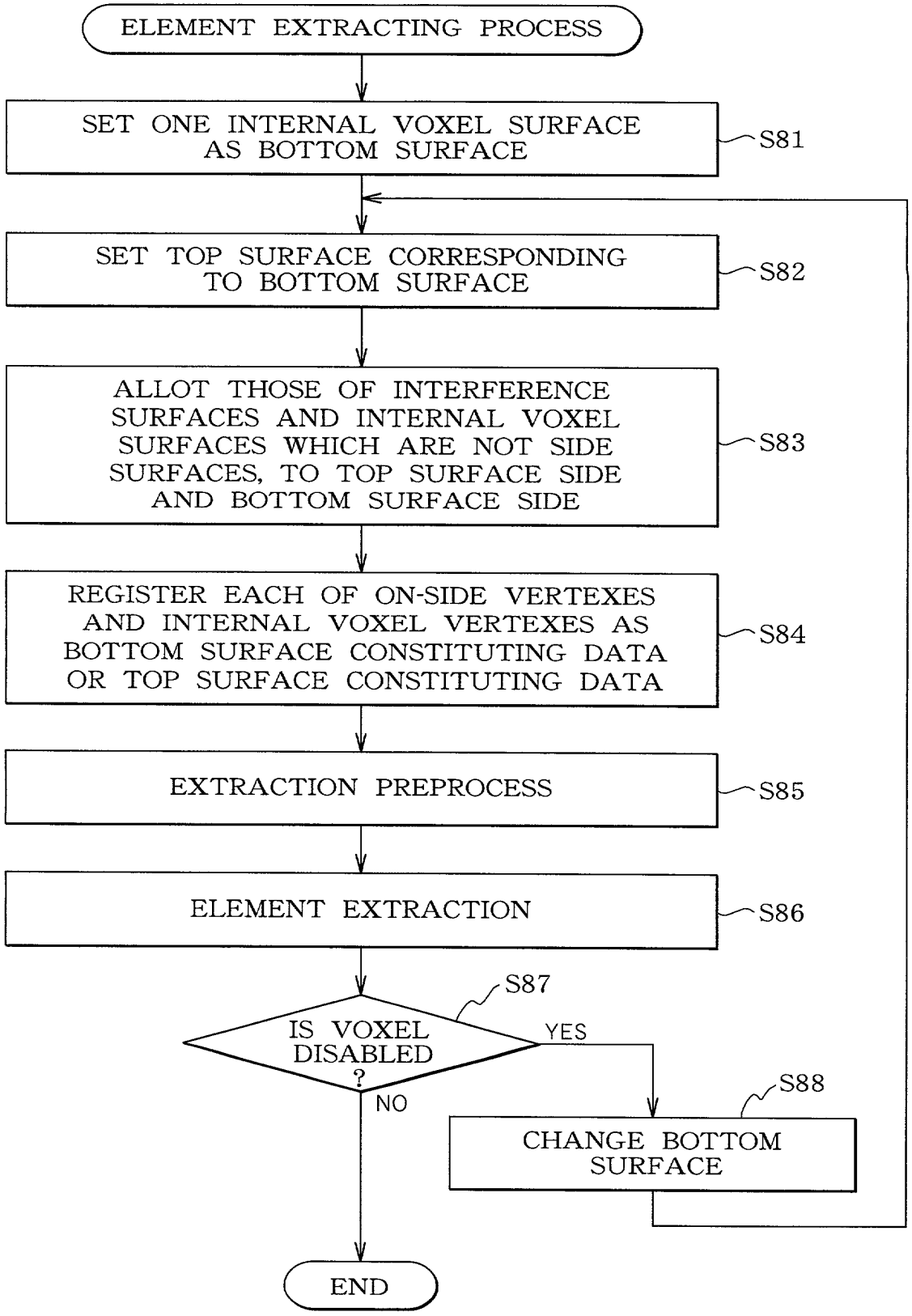
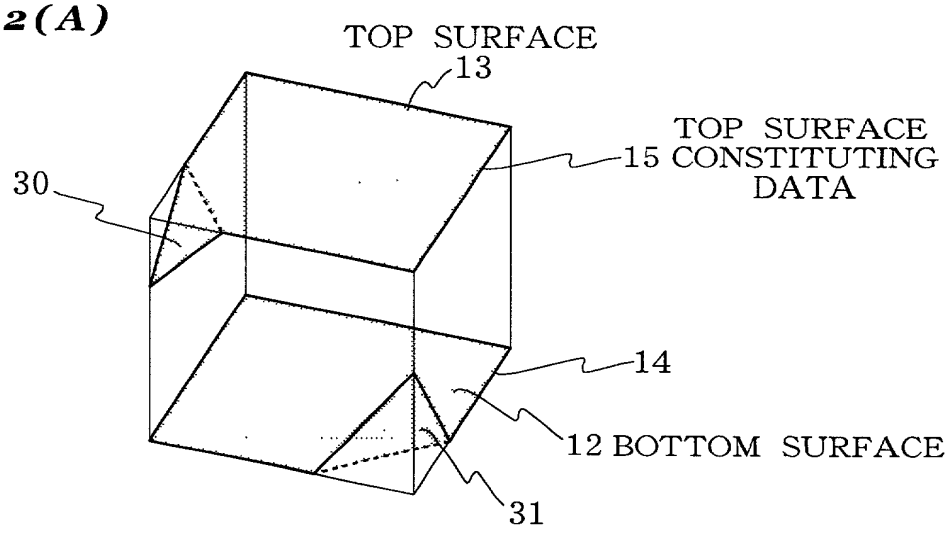

ELEMENT EXTRACTING PROCESS
SET ONE INTERNAL VOXEL SURFACE AS BOTTOM SURFACE
S81
SET TOP SURFACE CORRESPONDING TO BOTTOM SURFACE
S82
ALLOT THOSE OF INTERFERENCE SURFACES AND INTERNAL VOXEL SURFACES WHICH ARE NOT SIDE SURFACES, TO TOP SURFACE SIDE AND BOTTOM SURFACE SIDE
S83
REGISTER EACH OF ON-SIDE VERTEXES AND INTERNAL VOXEL VERTEXES AS BOTTOM SURFACE CONSTITUTING DATA OR TOP SURFACE CONSTITUTING DATA
S84
EXTRACTION PREPROCESS
S85
ELEMENT EXTRACTION
S86
S87
IS VOXEL DISABLED ?
YES
NO
S88
CHANGE BOTTOM SURFACE
END

FIG.12(A)



THICK SOLID LINE (——): SIDE DATA
THICK BROKEN LINE (----): DIAGONAL DATA

FIG.12(B)

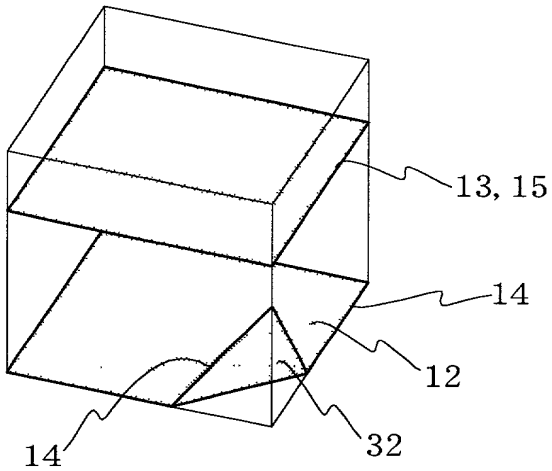


FIG.12(C)

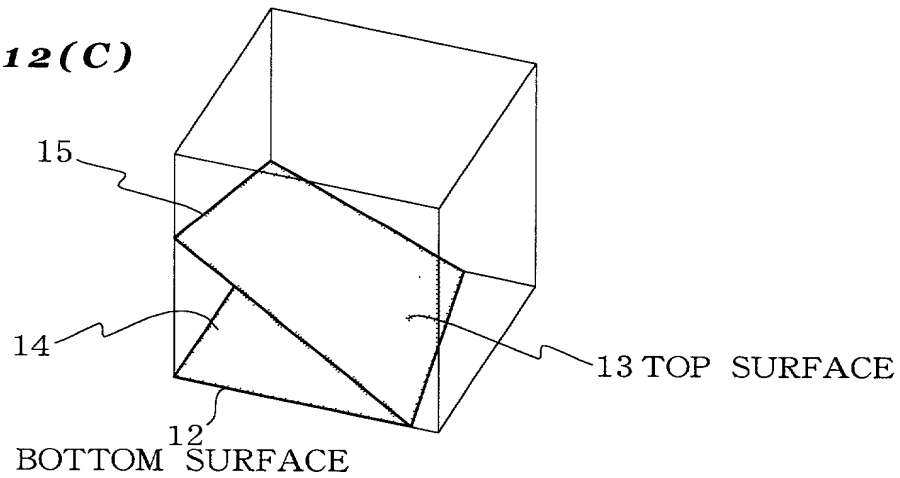


FIG.13(A)

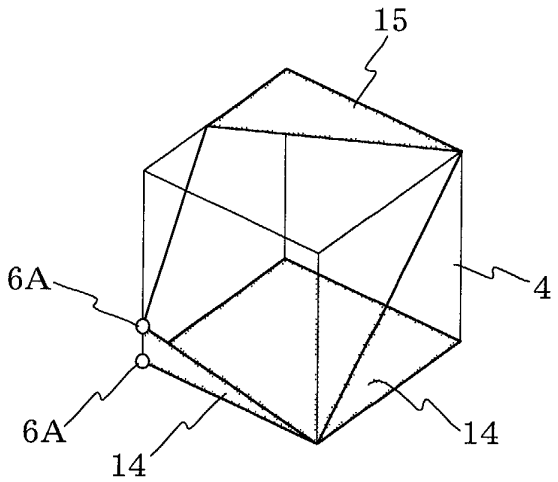


FIG.13(B)

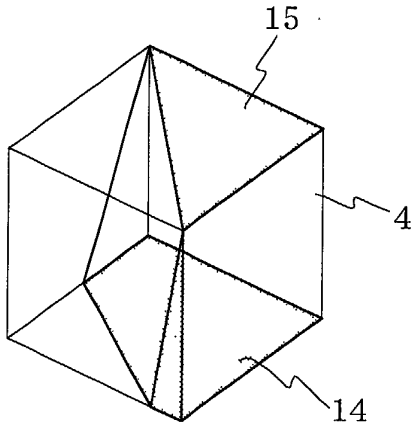
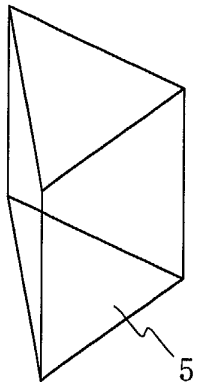


FIG.13(C)



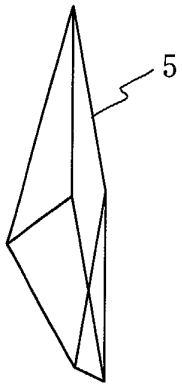


FIG.13(D)

FIG.14

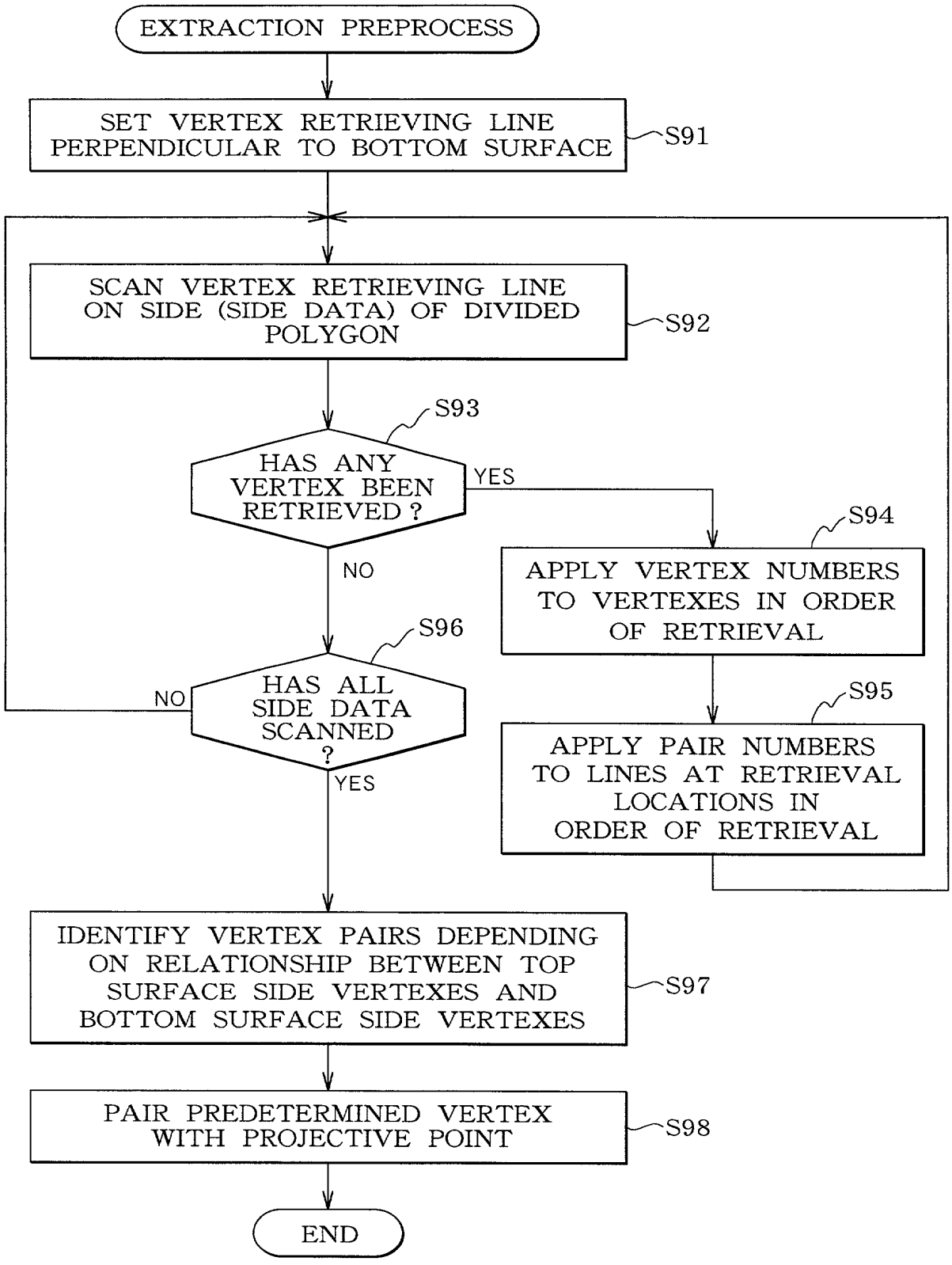

EXTRACTION PREPROCESS
SET VERTEX RETRIEVING LINE PERPENDICULAR TO BOTTOM SURFACE
S91
SCAN VERTEX RETRIEVING LINE ON SIDE (SIDE DATA) OF DIVIDED POLYGON
S92
S93
HAS ANY VERTEX BEEN RETRIEVED ?
YES
NO
S94
APPLY VERTEX NUMBERS TO VERTEXES IN ORDER OF RETRIEVAL
S96
HAS ALL SIDE DATA SCANNED ?
NO
YES
S95
APPLY PAIR NUMBERS TO LINES AT RETRIEVAL LOCATIONS IN ORDER OF RETRIEVAL
IDENTIFY VERTEX PAIRS DEPENDING ON RELATIONSHIP BETWEEN TOP SURFACE SIDE VERTEXES AND BOTTOM SURFACE SIDE VERTEXES
S97
PAIR PREDETERMINED VERTEX WITH PROJECTIVE POINT
S98
END

FIG.15(A)

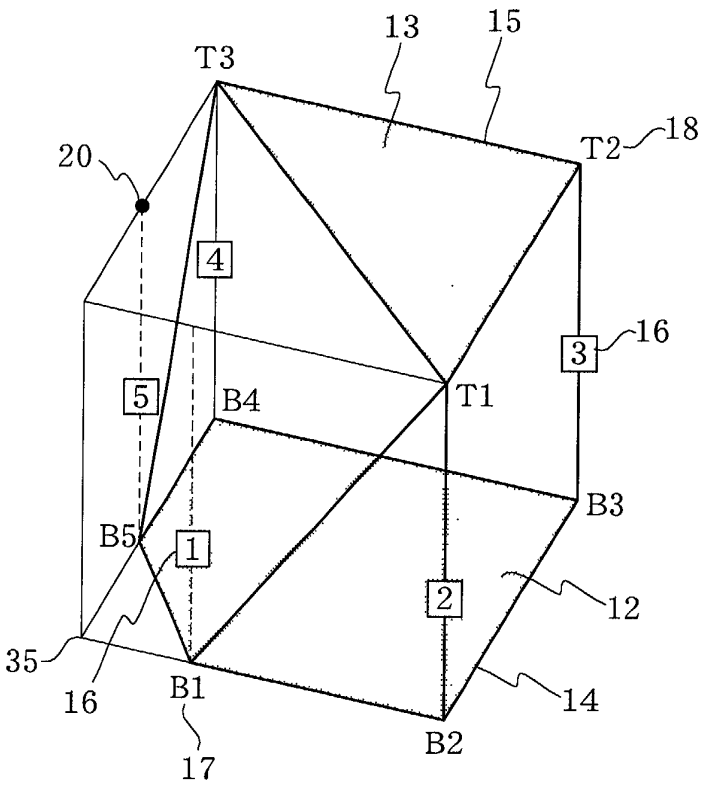


FIG.15(B)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA	
1	B1	NONE	
2	B2	T1	←PAIR
3	B3	T2	←PAIR
4	B4	T3	←PAIR
5	B5	NONE	

FIG.15(C)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA	
1	B1	T1	←PAIR
2	B2	T1	←PAIR
3	B3	T2	←PAIR
4	B4	T3	←PAIR
5	B5	T3	←PAIR

FIG.16(A)

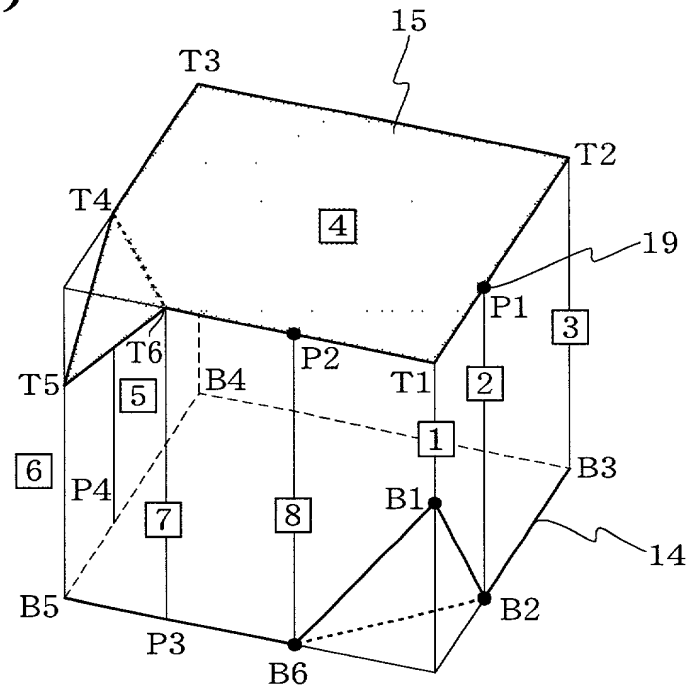


FIG.16(B)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA
1	B1	T1
2	B2	P1 → T2
3	B3	T2 → T3
4	B4	T3 → T4
5	P4 → B5	T4 → T5
6	B5 → B6	T5 → T6
7	P3 → B7	T6 → T7
8	B6 → B8	P2 → T8

FIG.17(A)

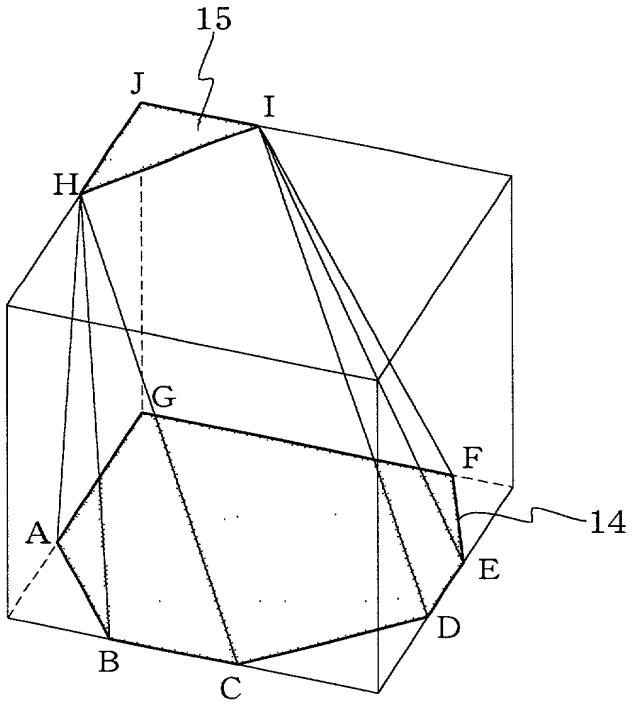


FIG.17(B)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA
1	A	
2	B	
3	C	
4	D	
5	E	
6	F	
7		I
8	G	J
9		K

FIG.18(A)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA
1	A	H
2	B	
3	C	
4	D	
5	E	
6	F	I
7	G	J

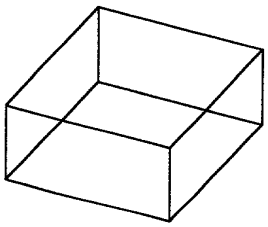
FIG.18(B)

PAIR DATA LIST

PAIR NUMBER	BOTTOM SURFACE CONSTITUTING DATA	TOP SURFACE CONSTITUTING DATA
1	A	H
2	B	H
3	C	H
4	D	I
5	E	I
6	F	I
7	G	J

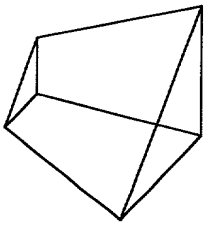
Translation of the PCT Application

FIG.19(A)



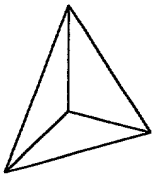
HEXAHEDRON COMPOSED SIX RECTANGLES

FIG.19(B)



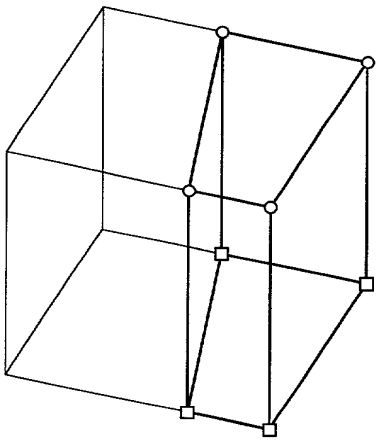
PENTAHEDRON COMPOSED OF TWO TRIANGLES AND THREE RECTANGLES

FIG.19(C)



TETRAHEDRON COMPOSED OF FOUR TRIANGLES

FIG.19(D)



HEXAHEDRON

○ : VERTEXES FROM SIDE DATA OF TOP SURFACE CONSTITUTING DATA

□ : VERTEXES FROM SIDE DATA OF BOTTOM SURFACE CONSTITUTING DATA

FIG.20(A)

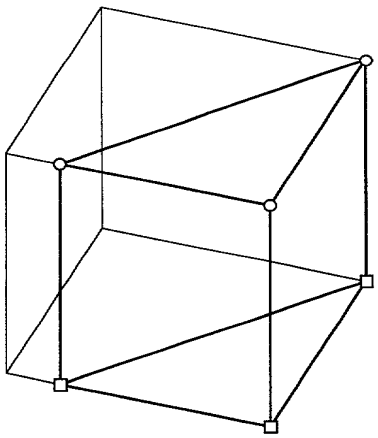


FIG.20(B)

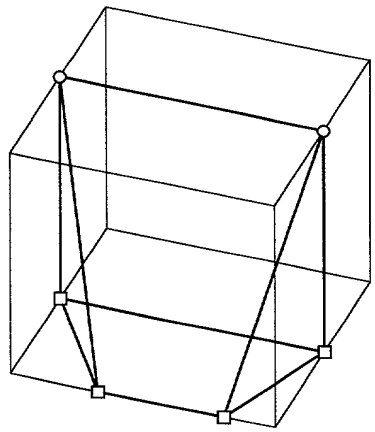


FIG.20(C)

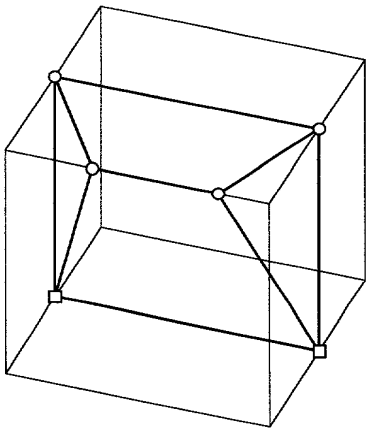
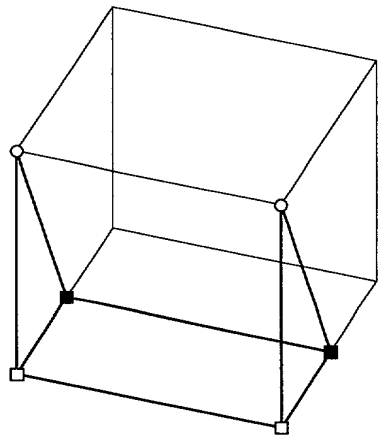


FIG.20(D)



○ : VERTEXES FROM SIDE DATA OF TOP SURFACE CONSTITUTING DATA

□ : VERTEXES FROM SIDE DATA OF BOTTOM SURFACE CONSTITUTING DATA

■ : POINTS WHERE VERTEX FROM SIDE DATA OF TOP SURFACE CONSTITUTING DATA IS SAME AS VERTEX FROM SIDE DATA OF BOTTOM SURFACE CONSTITUTING DATA

FIG.21(A)

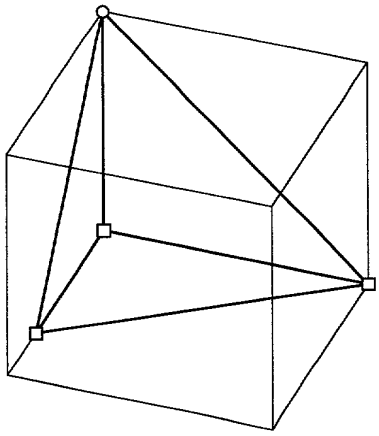


FIG.21(B)

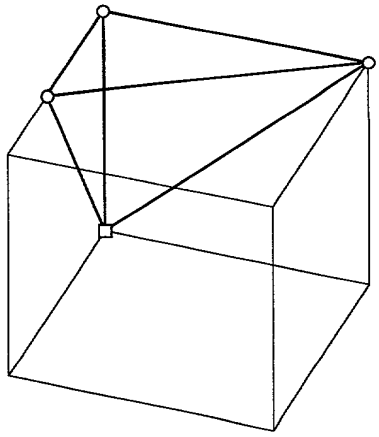


FIG.21(C)

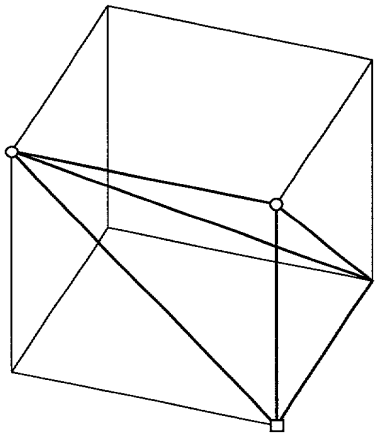


FIG.21(D)

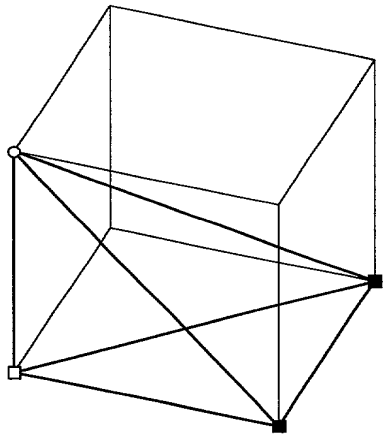
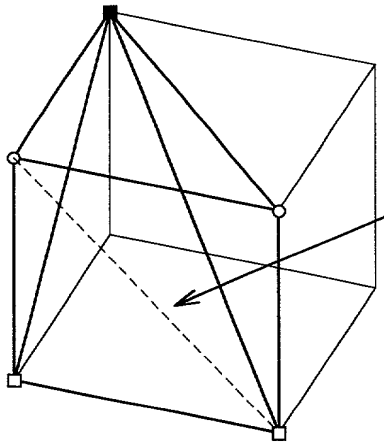


FIG.21(E)



○: VERTEXES FROM SIDE DATA OF TOP SURFACE CONSTITUTING DATA

□: VERTEXES FROM SIDE DATA OF BOTTOM SURFACE CONSTITUTING DATA

■: POINTS WHERE VERTEX FROM SIDE DATA OF TOP SURFACE CONSTITUTING DATA IS SAME AS VERTEX FROM SIDE DATA OF BOTTOM SURFACE CONSTITUTING DATA

FIG.22(A)

FIG.22(B)

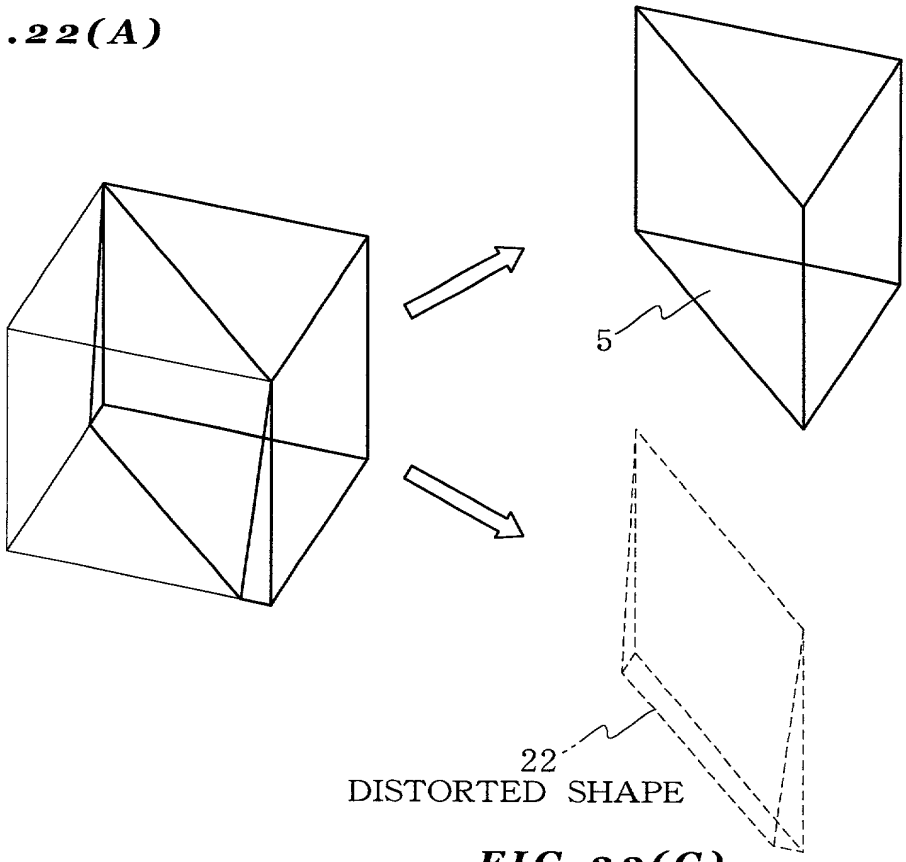


FIG.22(C)

FIG.22(D)

FIG.22(E)

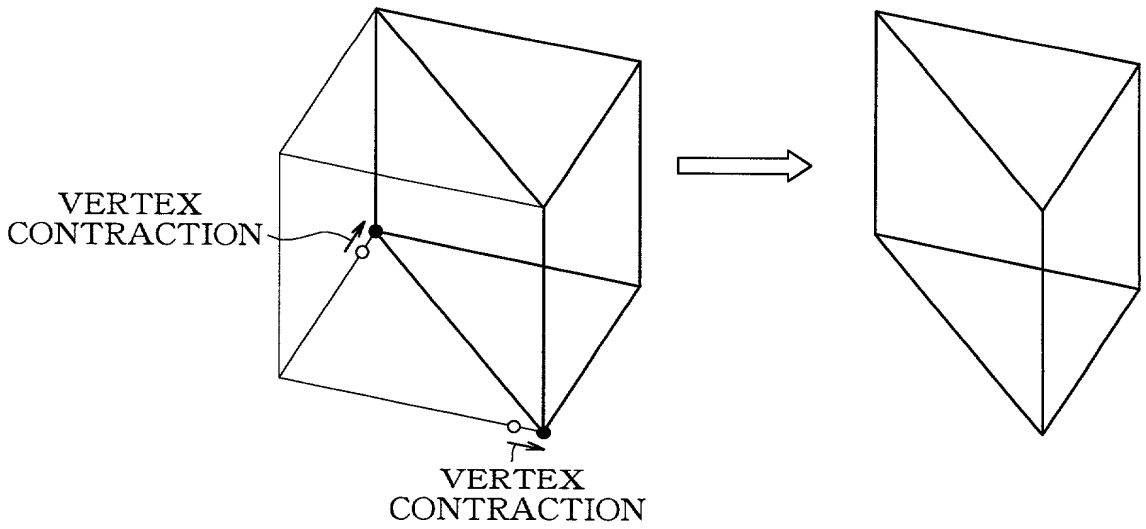


FIG.23

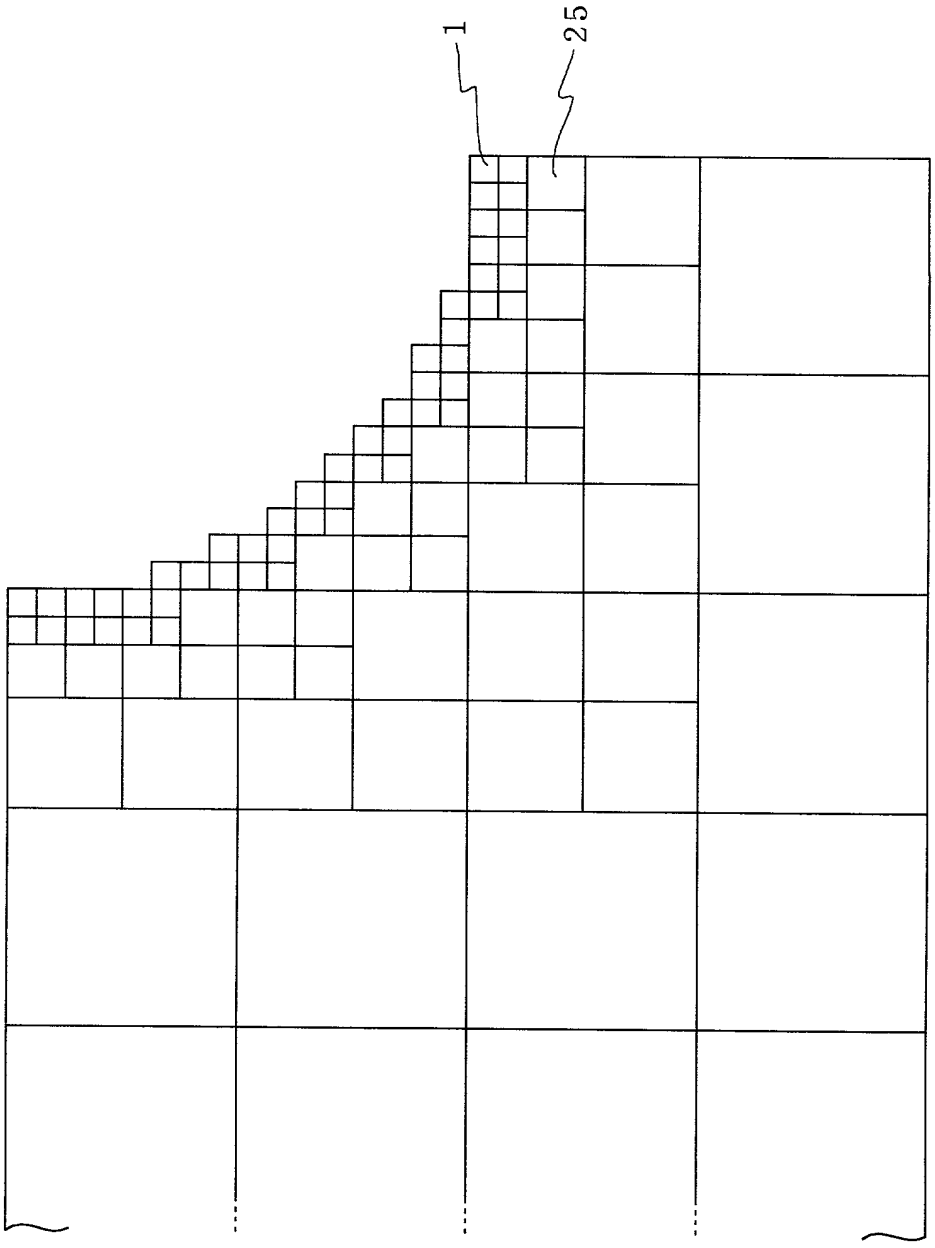


FIG.24

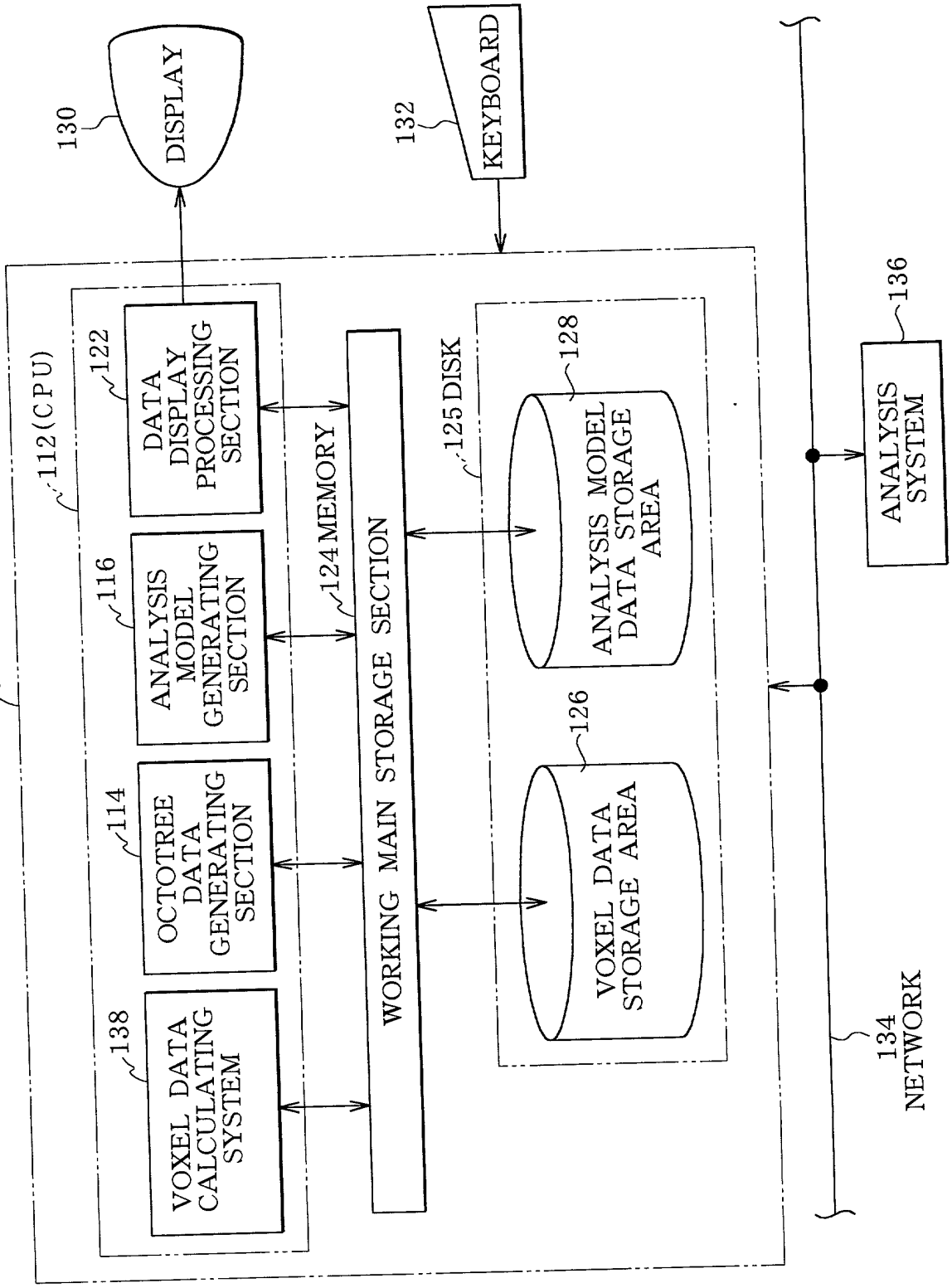

100 COMPUTER
112 (CPU)
DATA DISPLAY PROCESSING SECTION
122
ANALYSIS MODEL GENERATING SECTION
116
OCTOTREE DATA GENERATING SECTION
114
VOXEL DATA CALCULATING SYSTEM
138
124 MEMORY
WORKING MAIN STORAGE SECTION
125 DISK
ANALYSIS MODEL DATA STORAGE AREA
128
VOXEL DATA STORAGE AREA
126
130
DISPLAY
132
KEYBOARD
136
ANALYSIS SYSTEM
134
NETWORK

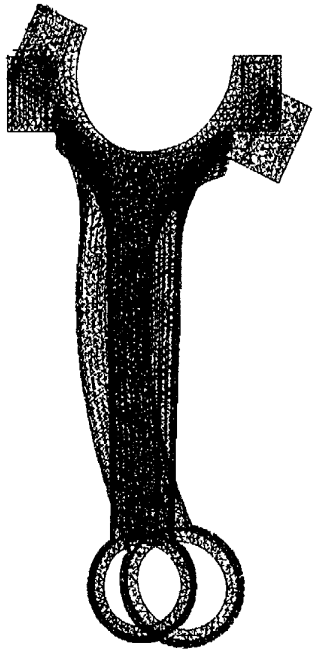
FIG.25

RESULTS OF APPLICATION OF PRESENT SYSTEM TO CONNECTING ROD

ANALYSIS MODEL CREATING METHOD	TIME REQUIRED TO CREATE THE SYSTEM [HOUR]	NUMBER OF ELEMENTS	PRIMARY SPECIFIC FREQUENCY [Hz]	DIFFERENCES FROM EXPERIMENTAL VALUES [Hz]
EXPERIMENTAL VALUES			3535.2	
PRESENT SYSTEM	4.2	16383	3554.6	+19.5 (+0.55%)
CONVENTIONAL METHOD (DIVISION OF TETRAHEDRON USING I-DEAS(TM))	4.3	37131	3187.6	-347.6 (-9.83%)

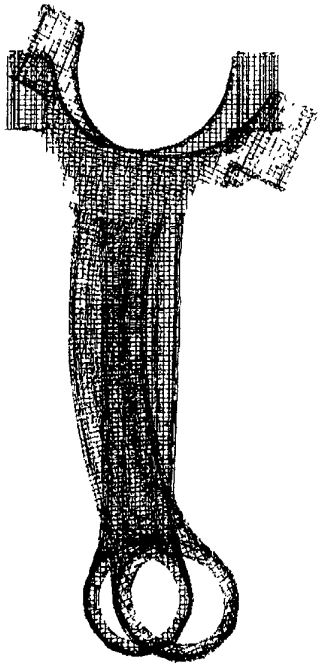
T06290 T6hE6860

FIG.26(A)



RESULTS OF ANALYSIS OF ANALYSIS MODEL CREATED USING CONVENTIONAL METHOD (I-DEAS(TM))

FIG.26(B)



RESULTS OF ANALYSIS OF ANALYSIS MODEL CREATED USING PRESENT SYSTEM

FIG.27(B)

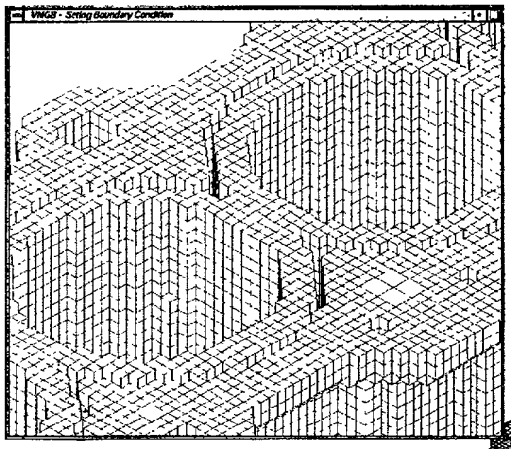
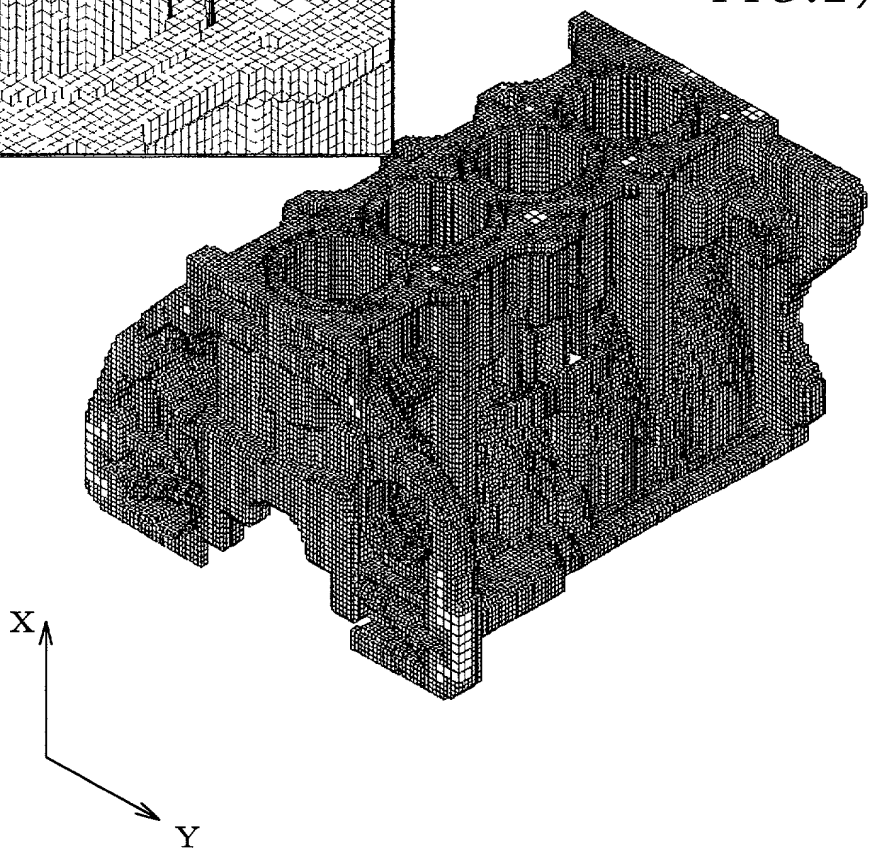


FIG.27(A)



ANALYSIS MODEL DATA
(NO SHAPE FITTING)

FIG.28(B)

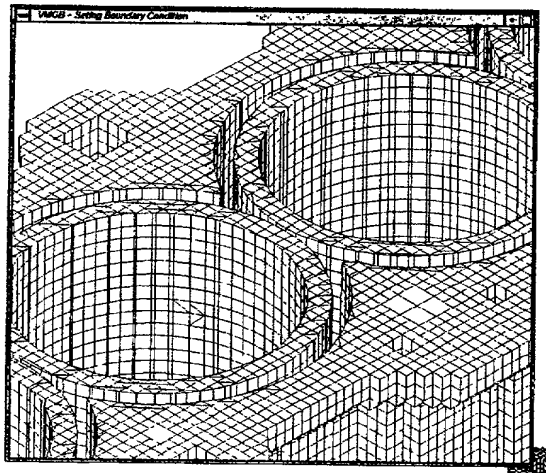
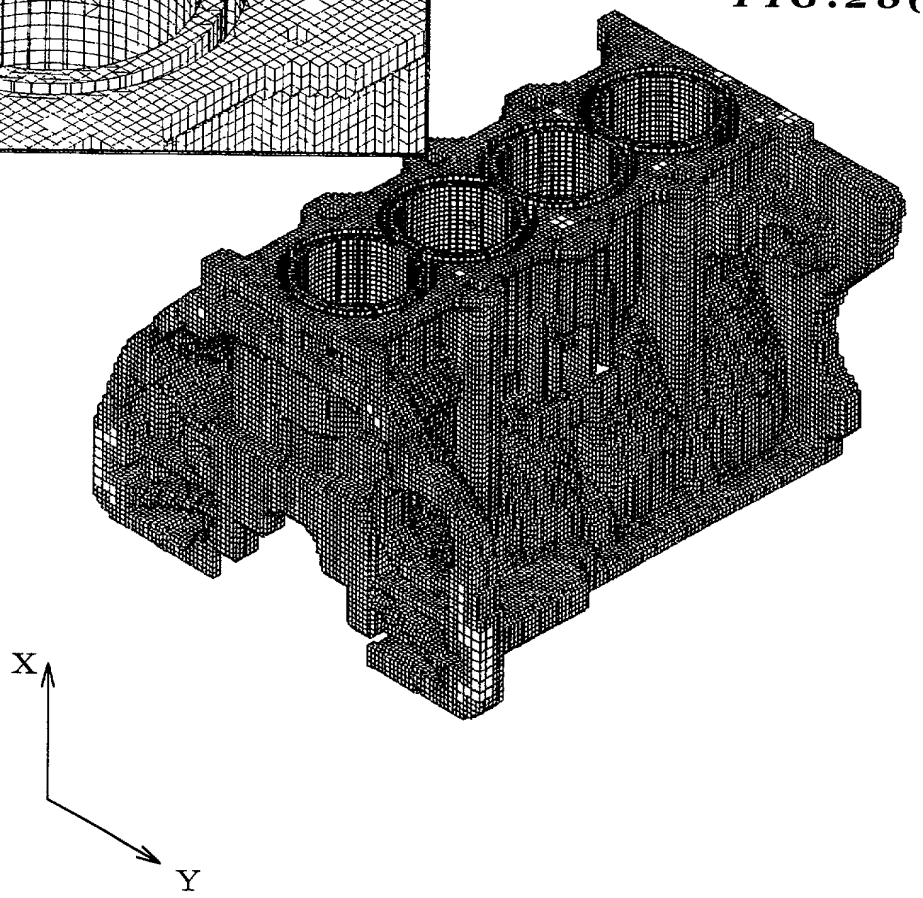


FIG.28(A)



ANALYSIS MODEL DATA
(WITH SHAPE FITTING)

FIG.29

RESULTS OF APPLICATION OF PRESENT SYSTEM TO CYLINDER BLOCK

ANALYSIS MODEL CREATING METHOD	TIME REQUIRED TO CREATE SYSTEM [HOUR]	PRIMARY SPECIFIC FREQUENCY [Hz]	DIFFERENCES FROM EXPERIMENTAL VALUES [Hz]
EXPERIMENTAL VALUES		507.8	
PRESENT SYSTEM (WITH SHAPE FITTING)	0.25	467.9	-39.9 (-7.9%)
PRESENT SYSTEM (WITHOUT SHAPE FITTING)	0.25	625.1	+117.3 (+23.1%)
CONVENTIONAL METHOD (DIVISION OF TETRAHEDRON USING I-DEAS(TM))	400	447.4	-60.4 (-11.9%)